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SAEPG-SIG 920-104

⑨ FINAL REPORT

EVALUATION OF GROUND-TO-GROUND JAMMING UTILIZING

RADIO SET AN/ALQ-3(XA-1)(U)

(~~PROJECT~~ 34-57-0073)

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FINAL REPORT
EVALUATION OF GROUND-TO-GROUND JAMMING
UTILIZING RADIO SET AN/ALQ-3(XA-1) (U)
(Project 34-57-0073)

August 1957

Electronic Warfare Department
U. S. ARMY ELECTRONIC PROVING GROUND
Fort Huachuca, Arizona

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FOREWORD

This report of jamming ground-based radars by a ground-based jammer utilizing Radio Set AN/ALQ-3(XA-1) has been prepared by the Electronic Warfare Department, U.S. Army Electronic Proving Ground, as a part of Project 34-57-0073 of the USAEPG Technical Program. These results are based on tests conducted to provide information on and establish parameters for ground-based jamming of ground-based radar equipment and represent the first action taken to provide this EW capability.

The AN/ALQ-3(XA-1) was originally designed as an unattended system for precision automatic air-to-ground jamming of S-band radar signals. The set was modified by the Electronic Defense Laboratory under a USASEL contract for use as a ground-to-ground jammer. The modifications were performed in the antenna system, the modulation circuits, and repackaging of the equipment for installation in a 1/4-ton truck, M 38A1. These modifications provided a wider choice of jamming parameters and increased the flexibility of operation of the test vehicle.

The tests were conducted at USAEPG during June 1957 by the Electronic Warfare Department with support provided by the 1st Signal Group, USAEPG.

Additional jamming tests against ground-based radars will be performed with the AN/ALQ-3(XA-1) mounted in an airborne platform. These tests will be conducted during the fall, 1957.

H. McD. BROWN
Colonel SigC
Chief, Electronic Warfare Department

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ABSTRACT

The results of ground-to-ground jamming tests utilizing the Radio Set AN/ALQ-3(XA-1) are set forth. These tests were conducted to obtain information on and parameters for ground-based jamming of ground-based radars.

The test results indicate that line-of-sight jamming of ground-based radars can be accomplished by jammer equipment of the AN/ALQ-3 (XA-1) type up to a range of 26,000 yards. This jamming range can be obtained for both main and side-lobe jamming. However, emplacing the radar in defilade or utilizing available terrain masking precludes this effectiveness.

In the modulation tests, random noise proved to be the most effective under all conditions. Tone modulation at the conical scan frequency of the target radar can be effective if the exact conical scan frequency of the radar is known.

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Section I. Summary

This report is the result of tests performed with the Radio Set AN/ALQ-3(XA-1) to determine its capability against ground-based S-band radars. Tests were conducted to determine optimum jamming modulations of the AN/ALQ-3(XA-1), its effectiveness as a jammer and a detecting device, the extent to which it interferes with friendly ground-based radar, and how terrain conditions influence the effectiveness of the AN/ALQ-3(XA-1).

Sine-wave and random-noise jamming modulations were imposed upon the transmitted signal of the Radio Set AN/ALQ-3(XA-1) to determine the most effective type. A sine-wave modulation of 60 cps and 1,100 cps was somewhat effective but random noise is the type of modulation that provides optimum jamming under general circumstances.

The AN/ALQ-3(XA-1) was found to be an effective detecting device through a wide latitude of attack angles and ranges. The signal strength required for lock-on was the determining factor of detection. The ability of the AN/ALQ-3(XA-1) to track-while-jamming was exhibited at all signal strengths greater than that required for lock-on. The AN/ALQ-3(XA-1) was effective in disrupting the automatic track feature of the Radar Set AN/MPQ-10A under radar line-of-sight conditions up to a range of 25,200 yds. The AN/ALQ-3(XA-1) was not effective when the radar was sited in defilade.

The interference with friendly ground-based radars is excessive unless terrain masking exists between the radar and the jammer.

Through all phases of the testing effective jamming by the AN/ALQ-3(XA-1) was possible only under radar line-of-sight conditions between the radar and jammer sites.

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Section II. Introduction

1. OBJECTIVE

The objective of the tests is to evaluate ground-to-ground countermeasures utilizing Radio Set AN/ALQ-3(XA-1) as a jammer against ground-based S-band radars.

2. BACKGROUND

Previous tests have been conducted with the Radio Set AN/ALQ-3(XA-1) basic equipment mounted in a shelter in conjunction with other jamming equipment and transported by a 2 $\frac{1}{2}$ -ton truck. In this installation the antenna used was a flush mounting, aircraft type, 65-degree helix, an original component of the set. The results indicated that the effective jamming range was up to and including 26,000 yds when employed against the AN/MPQ-10A mortar-locator radar set.

3. SCOPE

The tests in this report are conducted with a modified version of the AN/ALQ-3(XA-1). Mounted in a 1/4-ton vehicle, this version uses two narrow-beam horn antennas instead of the original helix antenna. Jamming effectiveness against the mortar locator Radar Set AN/MPQ-10A, a ground-based S-band radar, was determined. The AN/ALQ-3(XA-1) was also tested as a detecting device over various radar-jammer ranges. Interference by the AN/ALQ-3(XA-1) with friendly ground-based radars is evaluated, as well as the effects of terrain in siting this jammer.

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Section III. Description of Equipment

4. GENERAL

Radio Set AN/ALQ-3(XA-1) (fig. 1) is an unattended system for precision automatic jamming of radar signals. It automatically scans any portion of the frequency band from 2,650 to 3,350 Mc/s at a rate of 150 Mc/s and automatically intercepts, analyzes, selects, tracks, and jams continuous-tracking signals of the type emitted by gun-laying radar or ground-to-air missile guidance radar.

5. PRINCIPLE OF OPERATION

The receiving horn antennas of Radio Receiver R-594(XA)/ALQ-3 (fig. 2) which may be horizontally or vertically polarized, intercept all radar signals within the radiation pattern and frequency band of the receiver. The horn antenna can be positioned manually for maximum received signal by observing a special signal-strength meter, which gives a relative indication of received video peak amplitude. The antenna assembly is also equipped with a motor drive for automatic scanning. The azimuth position of the antenna is indicated on a control-panel azimuth indicator.

The receiver accepts signals of minimum strength from the automatic scan of a preset frequency range, amplifies and detects them, and supplies detected video pulses to the Electrical Pulse Analyzer RF-57(XA)/ALQ-3 for pulse analysis.

If the radar signal pulse width (pw) and pulse repetition frequency (prf) are within the preset limits of the system, the receiver locks on the accepted signal and tracks its frequency. The pulse analyzer contains a lost-target circuit, so that while in the tracking mode; if the radar signal disappears for more than one-half second, the lost-target circuit switches the system back to search mode. The pulse analyzer also contains a circuit that monitors the prf of the radar target signal during the tracking mode. If the prf of the signal increases above 5,000 pulses per second, or if the target signal is switched to cw emission, this circuit returns the system to the search mode. This circuit also prevents the output of one system from locking onto the output of another similar system and thus allowing the target to break away.

There are two modes of operation possible with the receiver: search and track. When the receiver is switched from search to track, another servo loop is energized and rough-tunes the Radio Transmitter



Fig. 1. AN/AIQ-3(XA-1) mounted in a 1/4-ton truck

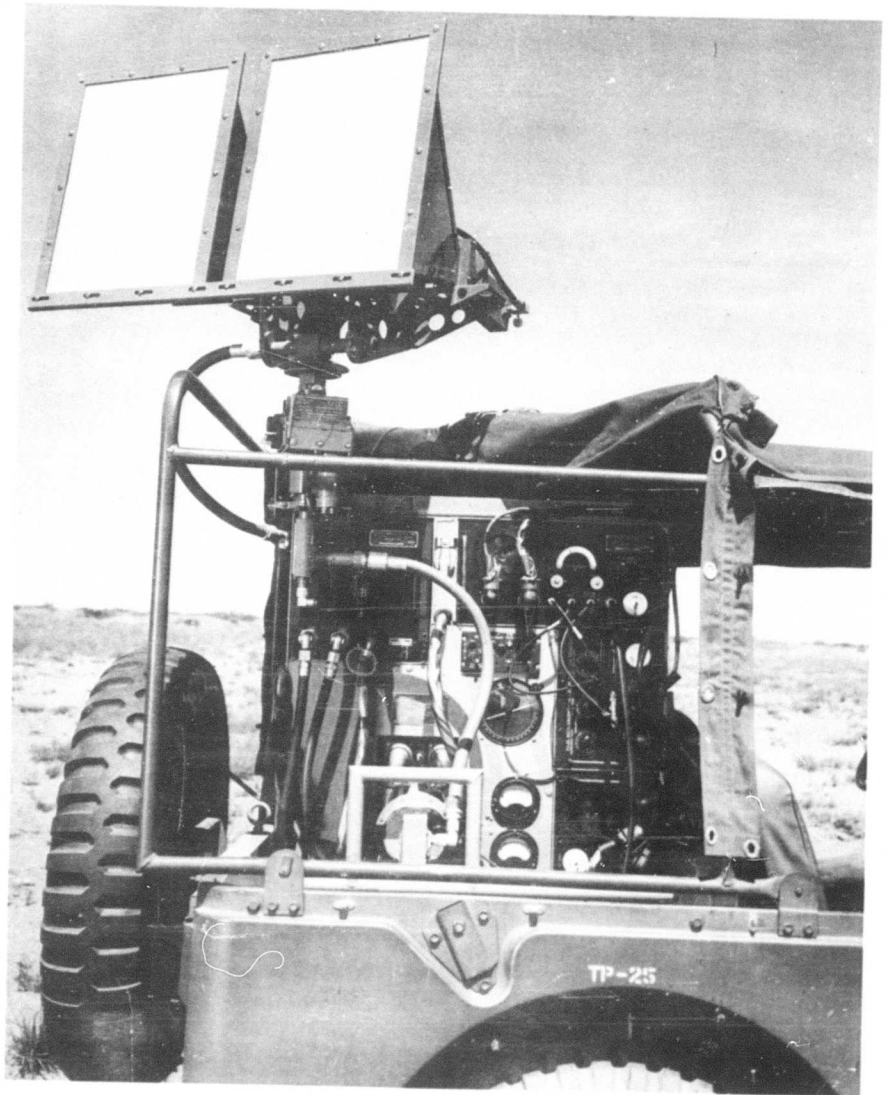


Fig. 2. AN/AIQ-3 equipment placement in rear of 1/4-ton truck

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T-444(XA)/ALQ-3 to the frequency of the receiver. After a transition time of approximately 2 seconds, the transmitter magnetron oscillator is energized and the set tracks while jamming.

Look-through is incorporated in the system to monitor the target while jamming it. The look-through employed is essentially a gating arrangement wherein the receiver and transmitter are alternately de-energized at a random rate.

The system also contains a command operational feature that re-sets the equipment for a new search operation when either the PRF-PW switch or the PW OUT-PW IN switch on the radio-set control is manipulated. The system then rejects the signal it is jamming and reverts to the search mode.

6. PHYSICAL CHARACTERISTICS

The weights of the components of the Radio Set AN/ALQ-3(XA-1) are as follows:

<u>Component</u>	<u>Weight (lbs)</u>
Transmitter T-444(XA)/ALQ-3	130
Receiver R-594(XA)/ALQ-3	44
Pulse Analyzer RF-57(XA)/ALQ-3	26
Electron-tube Liquid Cooler HD-177(XA)/ALQ-3	32
Power Supply PP-1062(XA)/ALQ-3	62
Radio Set Control C-1378(XA)/ALQ-3	1

7. TECHNICAL CHARACTERISTICS

a. The major technical characteristics of the AN/ALQ-3(XA-1) are as follows:

Frequency range	2,650 to 3,350 Mc/s on any preset portion of this range
Sensitivity	Signal amplitude: .01 microwatt (maximum)
	(50 db below one milliwatt)
Pulse-width control ranges:	
Narrower than	0.2 to 50 microseconds
Wider than	All (zero) to 5.0 microseconds
Pulse-repetition-frequency control range	100 to 4,000 pps
Antennas	Two horn antennas that can be installed for either vertical or horizontal polarization, but not used simultaneously

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Receiver scanning rate in
search mode (maximum). 150 Mc/s \pm 10 percent
System tracking rate*
(maximum). 100 Mc/s
Time interval between receiver
lock-on and the initiation of
transmitter tuning (maximum) . 3 seconds
Frequency deviation of jamming
signal from target signal
(maximum). \pm 2 Mc/s
Jamming:
Transmission period. Continuous except for look-through
Termination of jamming Approximately $\frac{1}{2}$ second after ab-
sence of target signal
Look-through:
Look-through on. Approximately 1 microsecond
Look-through off Approximately 19 microseconds
Power requirements. a. 115 v, 380 to 420 cps, single
phase, at 850 volt-amperes
b. 115 v, 380 to 1,000 cps, single
phase, at 3,000 volt-amperes
c. +28 v, dc, at 2.5 amperes
Rf power output 250 watts average over frequency
range
Spectrum. 200 watts average within any band
of 6 to 10 Mc/s, with a minimum
of 10 watts in any one part of
that band
Rf noise amplitude modulation
output Peak to rms ratio = $3\frac{1}{2}$ to 1
Rf noise frequency spectrum . . 6 to 10 Mc/s
Sine-wave amplitude modulation. 30 to 5,000 cps \pm 1.5 db single
tone sine wave
Tuning system Automatic receiver and transmitter
tuning; direct reading in frequency

b. The major technical characteristics of the AN/MPQ-10A (figs. 3 and 4) are as follows:

Frequency range 2,740 to 2,960 Mc/s
Pulse repetition frequency. . . 1,000 pps
Peak power output 200 kw

* The AN/ALQ-3(XA-1) system is designed to track radars which are tuned continuously, but not those which jump frequency.

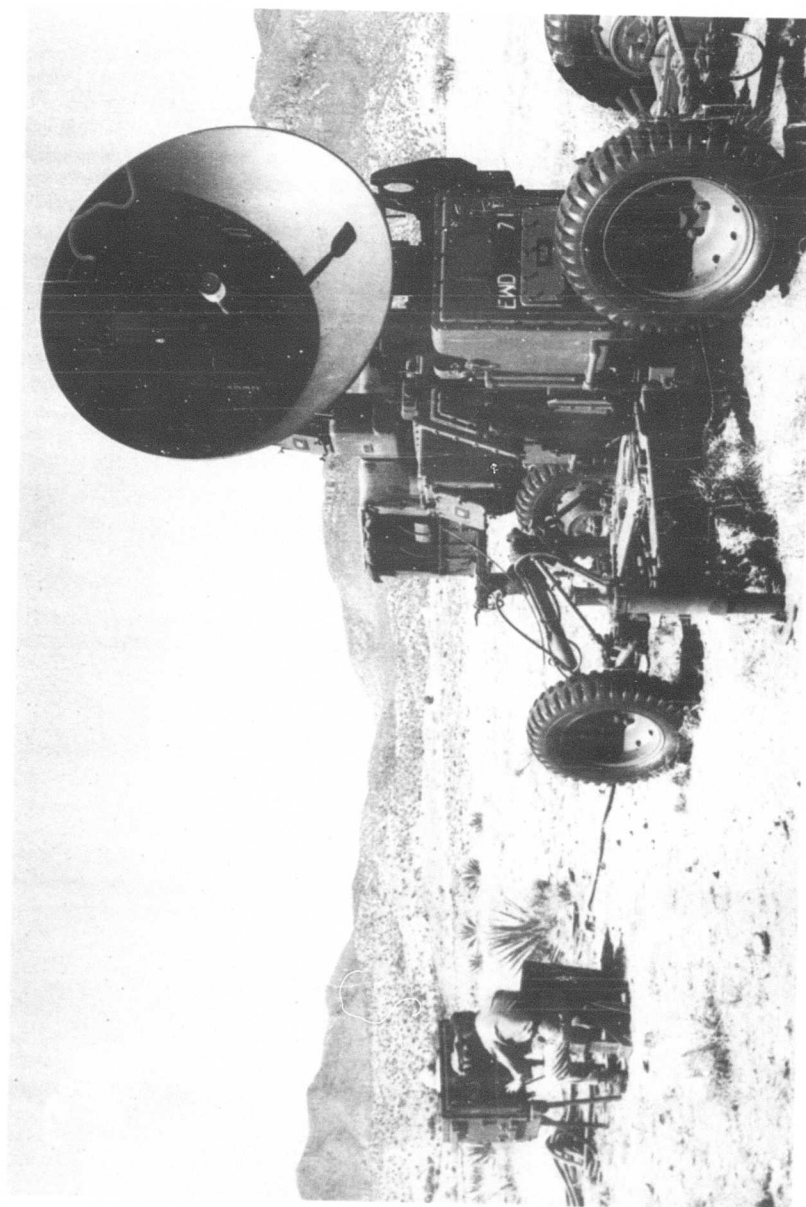


Fig. 3. Radar Set AN/MPQ-10A in operation



Fig. 4. Radar Set AN/MPQ-10A control unit

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Average power output.	180 w
Antenna beam width without conical scan	5 degrees
Primary power requirement . . .	115 v, 60 cps, 3 phase ac, 6 kw (max)
Azimuth coverage.	6,400 mils, continuous
Sector scan width	200 to 800 mils, adjustable
Automatic tracking rates:	
Elevation.	250 mils per sec (max)
Azimuth.	350 mils per sec (max)
Slant range.	1,000 yds per sec (max)
Sector scanning rate.	800 mil cycle in 3 sec
Resolution:	
Azimuth.	90 mils
Elevation.	90 mils
Range	20,000 yds max, 500 yds min

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Section IV. Tests to Determine Optimum Modulation of Jamming Signal

8. TEST 1. EFFECTS OF VARIOUS JAMMING MODULATIONS ON THE AN/MPQ-10A

a. Purpose

The purpose of test 1 is to determine the most effective type of modulation for use against the radar AN/MPQ-10A and to determine whether the AN/MPQ-10A is particularly susceptible to specific modulation frequencies.

b. Procedure

The AN/MPQ-10A was sited on relatively high ground to enable the acquisition of an isolated, fixed echo target and to allow some freedom in the selection of sites for the jammer at various line-of-sight, jammer-to-radar ranges from 4,000 to 26,000 yds. CW, modulation by noise, and modulation by sine-wave frequencies from 40 to 1,200 cps were imposed upon the jammer output at each location.

The radar set was placed in operation, and after the fixed target was found by manual tracking, the set was switched to the automatic tracking mode. The AJ (anti-jam) switch was in the ON position.

c. Results

(1) The first fixed target was at an approximate range of 4,500 yds, and the jammer-to-radar range was 4,150 yds. The relationship between the three sites is shown in fig. 5. The jammer was placed in operation, using different modulations, with the following results:

(a) Noise resulted in immediate disruption of the automatic tracking mode.

(b) Various sine-wave frequencies between 40 and 1,200 cps resulted in cluttering of the scope and jittering of the antenna, followed by disruption of tracking. Use of 1,100 cps caused a breaking of track more quickly than when the sine waves of other frequencies were applied and was therefore judged the most effective.

(c) An effective jamming condition was produced on the radar at this range with each of the above modulations, even when the jammer antenna was oriented at 45 deg with respect to the radar.

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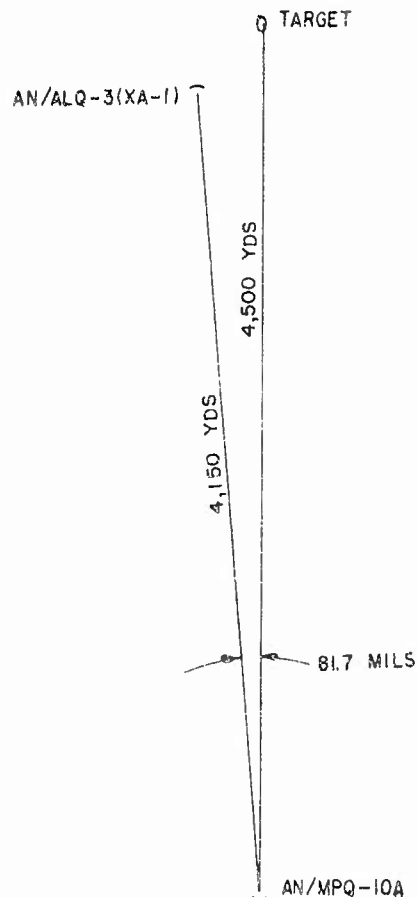


Fig. 5. Site relationship, test 1, step 1

(2) The second isolated, fixed target for the radar was a local commercial radio tower, located approximately 6,000 yds from the radar. The jammer was located at a range of 9,900 yds from the radar. The relationship between sites is shown in fig. 6. The procedure of automatic tracking on the fixed target, with the AJ feature of the radar receiver in use, and jamming was repeated with the following results:

(a) Noise modulation resulted in disruption of the automatic tracking mode.

(b) Various modulating sine-wave frequencies between 40 and 1,200 cps resulted in cluttering the J-scope presentation and jittering of the antenna, but the set maintained automatic track.

(c) A cw signal resulted in immediate disruption of the automatic tracking mode; it was more effective than a noise-modulated signal.

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The radar receiver was then operated with the AJ switch in the OFF position. All types of jamming signals completely obliterated radar echoes from the scope presentation and disrupted the tracking of the antenna.

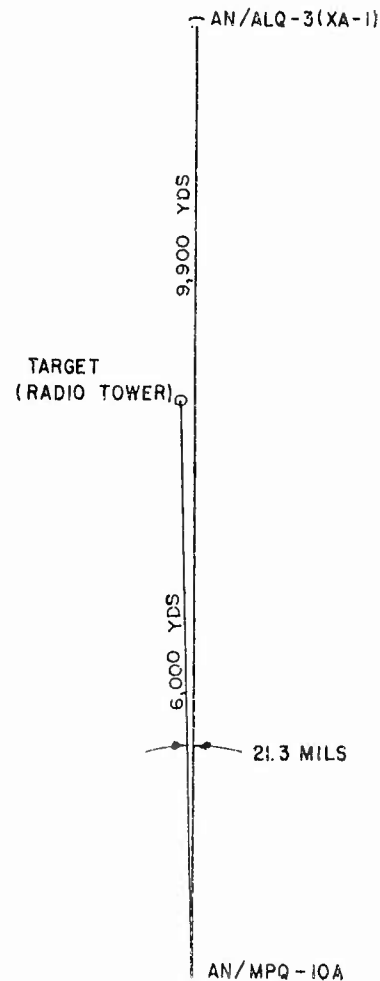


Fig. 6. Site relationship, test 1, step 2

(3) The radio tower was again used as the isolated, fixed echo target. The jammer-to-radar range was 25,400 yds, as shown in fig. 7. The procedure of automatic tracking, with the AJ of the radar receiver in use, and jamming was repeated with the following results:

(a) Noise type of modulation resulted in disruption of the automatic tracking mode.

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(b) In general, sine-wave modulations were not effective as in the previous test. However, it was found that with slow, careful tuning of the modulating frequency in the vicinity of 60 cps, a breaking of track at the radar could be produced. If the exact frequency of the radar's conical scan is used, jamming can be obtained, but this type of jamming is not so well defined as that with a noise-modulated signal.

(c) The radar receiver was then operated without using the AJ system. Results show no perceptible difference between operation with or without AJ. This is attributed to a relatively weaker signal being received at a range of 25,400 yds than at 9,900 yds.

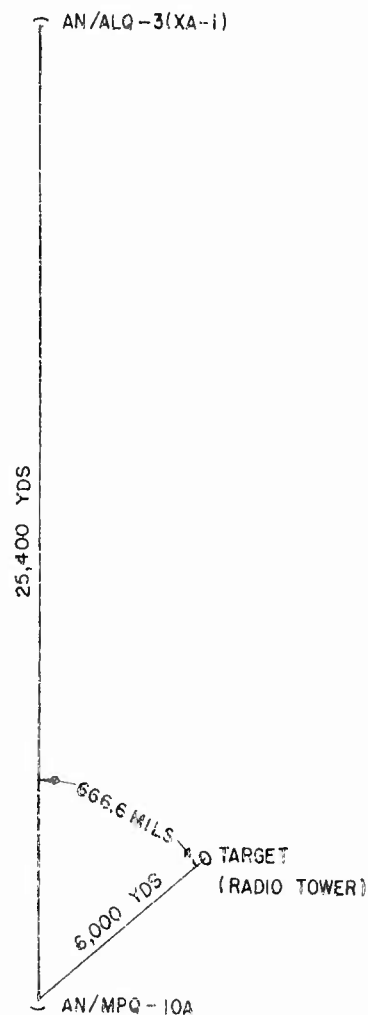


Fig. 7. Site relationship, test 1, step 3

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Section V. Effectiveness against S-Band Ground-Based Radars

9. TEST 2, EFFECTIVENESS OF THE AN/AIQ-3(XA-1) AS A DETECTING DEVICE

a. Purpose

The purpose of test 2 is to determine the effectiveness of the AN/AIQ-3(XA-1) in intercepting ground-based radars operating in the S-band.

b. Procedure

The mortar-locator Radar Set AN/MPQ-10A was located at the same site as in test 1 since a previous defilade site yielded insufficient lock-on signal at the jammer. The jammer set was located at various ranges from the radar site, with consideration given to maintaining radar line of sight. In each range, the jammer and radar antennas were varied in elevation and azimuth to the limits of intercept capability. The setting of the jammer antenna was the independent variable. It was first varied in azimuth in increments of 100 mils measured from 0-deg aspect.* Then it was varied in elevation in increments of 100 mils above the initial 100-mil elevation necessary to decrease ground clutter. The extent of variation of the radar antenna with respect to a particular setting of the jammer antenna was a dependent variable, except when the radar antenna was circularly polarized. In each case the radar antenna was moved until a sufficient signal to maintain lock-on was lost at the jammer site.

c. Results

(1) The first jammer site was at a range of 3,850 yds from the radar. This location proved to be too near for normal operation of the jammer receiver. Data were not collected at this range.

(2) The second jammer site was at a range of 9,900 yds from the radar. Possible masking by terrain features was present at the jammer site to 600 yds from the jammer site, as shown in fig. 8. The

* Aspect as used in this report is defined as the angular relationship between the jammer antenna and the radar antenna in both the horizontal and vertical planes. For example, 0-deg aspect occurs when the radar and jammer antennas are pointed directly toward each other.

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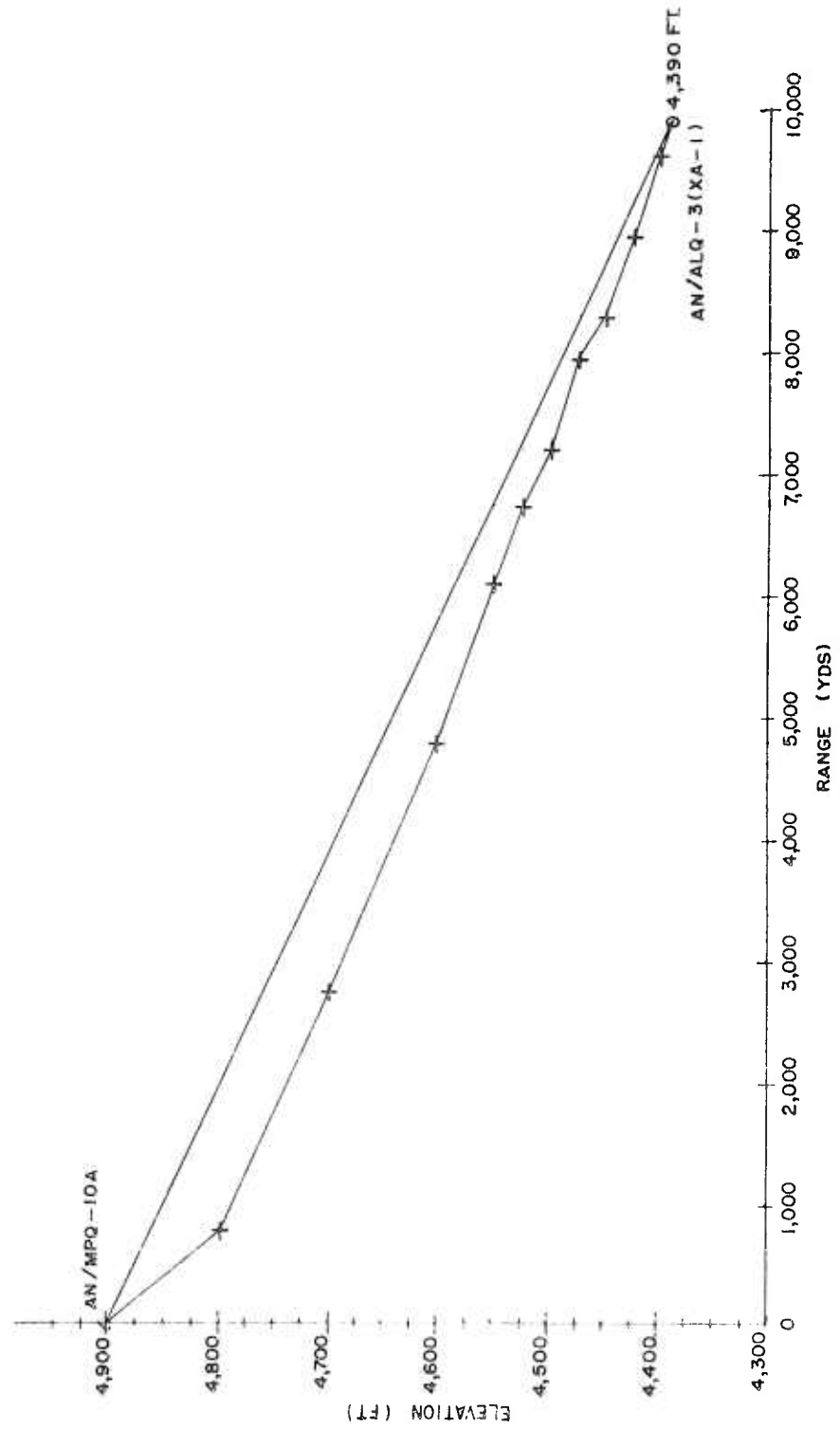


Fig. 8. Profile, indicating possible terrain masking, test 2, step 2

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signal strength of the received signal was still strong at this location but of a lesser magnitude than that experienced at site 1, thereby permitting a detailed examination of the ability of the jammer as a detecting device.

(a) The jammer antenna was varied in elevation in increments of 100 mils. The radar antenna was elevated until the jammer receiver lost the transmitting signal, as shown in fig. 9(A).

(b) The jammer antenna was reset in the original elevation of 0-deg aspect. The radar antenna was set at 100 mils elevation. The azimuth of the jammer antenna was varied in increments of 100 mils, while the radar antenna was varied in azimuth in each direction until the jammer receiver lost the radar signal, as shown in fig. 9(B).

(c) The radar set was then operated in sector-scan mode. The jamming antenna was oriented at 0-deg aspect. Various widths of scan were tried while the degree of detection was noted at the jammer, as follows:

<u>Radar sector width</u> <u>(in mils)</u>	<u>Jammer reaction</u>
200.	Lock-on maintained
300.	Lock-on maintained
400.	Brief loss on extremes
500.	Lock-on disrupted

(3) The third jammer site was at a range of 25,400 yds. The relative ability of the jammer as a detecting device was again tested by the same method as in jammer site 2.

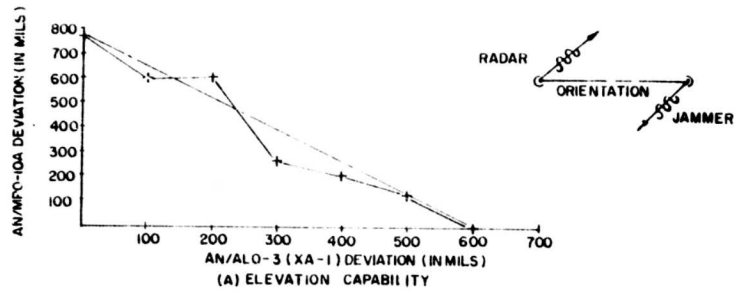
(a) The jammer antenna was varied in elevation, as shown in fig. 10(A).

(b) The jammer antenna was varied in azimuth, as shown in fig. 10(B).

(c) The radar set was then operated in a sector-scan mode, while the jammer antenna was oriented at 0-deg aspect. The sector width was varied and, in this case, the jammer receiver maintained lock-on to a maximum sector width of 800 mils.

(4) The fourth jammer site was at a range of 32,750 yds from the radar. The relative ability of the jammer as a detecting device was again tested by the same method as in jammer site 2.

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(A)

JAMMER ANT. EL. (IN MILS)	RADAR ANT. EL. (IN MILS)
0	100 - 760
100	100 - 600
200	100 - 600
300	100 - 250
400	100 - 200
500	100 - 120
600	NO SIGNAL

(B)

JAMMER ANT. AZ (IN MILS)	RADAR ANT. AZ (IN MILS)
0	- 625 TO +625
100	- 600 TO +700
200	- 700 TO +600
300	- 620 TO +600
400	- 260 TO +400
500	- 240 TO +280
600	- 240 TO +220
700	NO SIGNAL

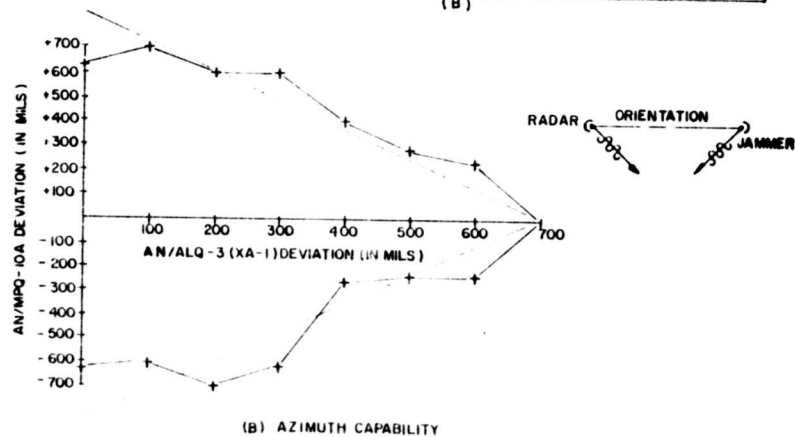
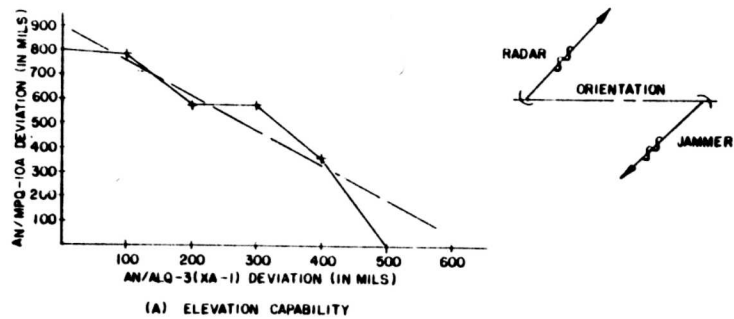


Fig. 9. Jammer intercept capability in (A) elevation and (B) azimuth, test 2, step 2. Trend indicated by graphical average.

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JAMMER ANT. EL. (IN MILS)	RADAR ANT. EL. (IN MILS)
0	100-800, 1,250-1,800
100	100-780, 1,240-1,600
200	100-580, 1,360-1,600
300	100-580
400	100-360
500	NO SIGNAL

JAMMER ANT. AZ (IN MILS)	RADAR ANT. AZ (IN MILS)
0	-800 TO +1,000
100	-560 TO +980
200	-480 TO +900
300	-350 TO +900
400	-400 TO +830
500	-140 TO +680
600	NO SIGNAL

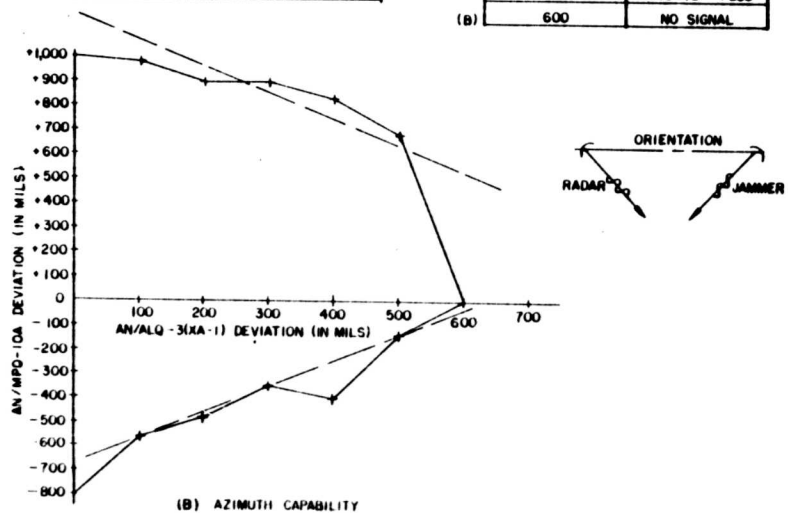


Fig. 10. Jammer intercept capability in (A) elevation and (B) azimuth, test 2, step 3. Trend indicated by graphical average.

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(a) The jammer antenna was varied in elevation, as shown in fig. 11(A).

(b) The jammer antenna was varied in azimuth, as shown in fig. 11(B).

(c) The test for detection capability of the jammer while radar is operated in sector scan was not performed at this range of 32,750 yds.

10. TEST 3. EFFECTIVENESS OF THE JAMMER IN THE TRACK-WHILE-JAM MODE

a. Purpose

The purpose of test 3 is to determine the effectiveness of the AN/ALQ-3(XA-1) when used in the track-while-jam mode of operation against a ground-based radar such as the AN/MPQ-10A.

b. Procedure

This test was run concurrently with test 2. The time required for the jammer equipment to change from search to track mode, and from track mode to track-while-jam mode was observed during all phases of relative antenna orientations and at various ranges as conducted in the execution of test 2. The effect of jamming was also noted at each position.

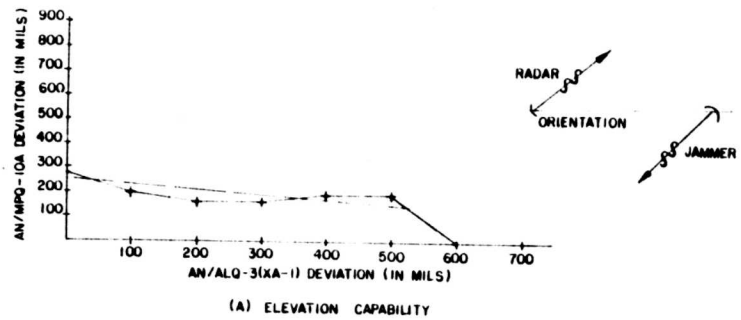
c. Results

(1) Time from Search to Track Mode. The time for lock-on is instantaneous once the receiver is tuned to the incoming signal. The time for selection of the transmitted signal is a variable dependent upon the adjustment of the sector tuning width. This sector can be adjusted to a minimum width of 50 Mc/s and a maximum width of 700 Mc/s. The scanning rate in search mode is 150 Mc/s. Therefore, the possible time variations are 0.33 sec to 4.67 sec.

(2) Time from Track to Track-While-Jamming. This time was determined to be a constant of 2.8 sec, for it is a function dependent upon the circuit parameters of the jammer system.

(3) Effect of Jamming. A jamming signal was noted at each of the maximum deviations of relative antenna orientations. The amount of jamming signal imposed at the maximum deviations was considerably less than that produced at 0-deg aspect. It is considered that the jamming signal is of such magnitude as to cause difficulty in spotting a weak echo signal, e.g., a mortar round in flight.

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JAMMER ANT. EL. (IN MILS)	RADAR ANT. EL. (IN MILS)
0	100 - 280
100	100 - 200
200	100 - 160
300	100 - 160
400	100 - 190
500	100 - 190
600	NO SIGNAL

JAMMER ANT. AZ (IN MILS)	RADAR ANT. AZ (IN MILS)
0	+550 TO -850
100	+450 TO -830
200	+350 TO -790
300	+300 TO -750
400	+50 TO -550
500	-50 TO -550
600	+10 TO -250
700	NO SIGNAL

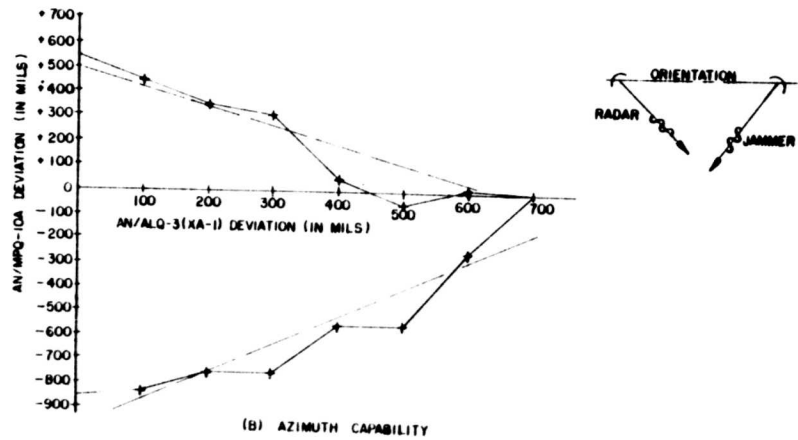


Fig. 11. Jammer intercept capability in (A) elevation and (B) azimuth, test 2, step 4. Trend indicated by graphical average.

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11. TEST 4. EFFECTIVENESS AGAINST MORTAR-TRACKING RADAR

a. Purpose

The purpose of test 4 is to determine the effectiveness of the AN/ALQ-3(XA-1) against the Mortar-Tracking Radar AN/MPQ-10A while it is in the track mode on a moving target.

b. Procedure

The moving target in this test was an 81-mm mortar round while in flight. The radar, mortar, and jammer were sited in an approximately straight line, as shown in fig. 12. The radar and mortar sites remained fixed at 6,000 yds; whereas the jammer site was progressively increased in range with due consideration given to maintaining line of sight between radar and jammer. The mortar was fired at targets at a range of 2,600 yds on one of two bearings relative to the radar site, that is, at either 0 mils (target 1) or 635 mils (target 2).

The radar was initially adjusted by sector scanning the expected path of the mortar-round trajectory while a round was fired. Several rounds were then fired to enable proper adjustment for automatic tracking by the AN/MPQ-10A. During this time the jammer receiver was placed in operation and the antenna was manually oriented to produce a maximum received signal. This resulted in the stopping of the search mode and lock-on to the signal from the radar. Thereafter successive rounds were fired and the radar was allowed to stabilize in the track mode of operation before the jamming transmitter was manually switched on. The effectiveness of breaking the radar's track with the jammer located at progressively increased ranges is shown in the test results.

c. Results

(1) The first jammer site offering radar line of sight was 6,500 yds to the rear of the mortar site, or 12,500 yds from the radar, as shown in fig. 12. Mortar fire was directed on target 2. The tracking of the radar was effectively disrupted by the jamming signal in 11 out of 14 rounds acquired by the radar. Three types of modulation were used during the jamming mode: (1) noise, (2) 60 cps, and (3) 1,100 cps. The percentages of success were as follows:

1. Noise - 3 jams for 3 trials - 100 percent
2. 60 cps - 6 jams for 8 trials - 75 percent
3. 1,100 cps - 2 jams for 3 trials - 66 percent

The over-all average percentage of jamming effectiveness was 80 percent from a range of 12,500 yds.

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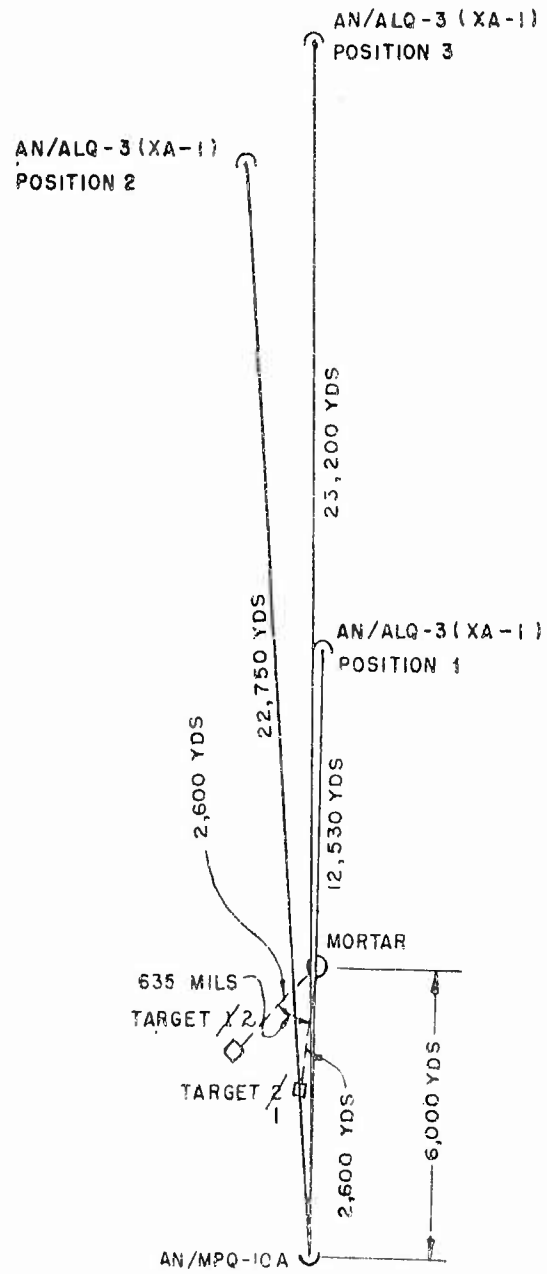


Fig. 12. Siting arrangement for test 4

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(2) The third jammer site provided a range of 25,200 yds between radar and jammer. The radar line-of-sight condition in this location was slightly masked by intervening terrain at a range of 2,460 yds and extending to 5,600 yds from the jammer, but with an average depth of only 10 ft, as shown in profile, fig. 13. Mortar fire was directed at target 1, 0-mil bearing with the radar site. The jamming was effective in 7 out of 10 rounds acquired by the radar. The degree of jamming at this extended range was not as pronounced as at 12,500 yds, since the disruption of the tracking mode did not occur immediately upon transmission of the jamming signal.

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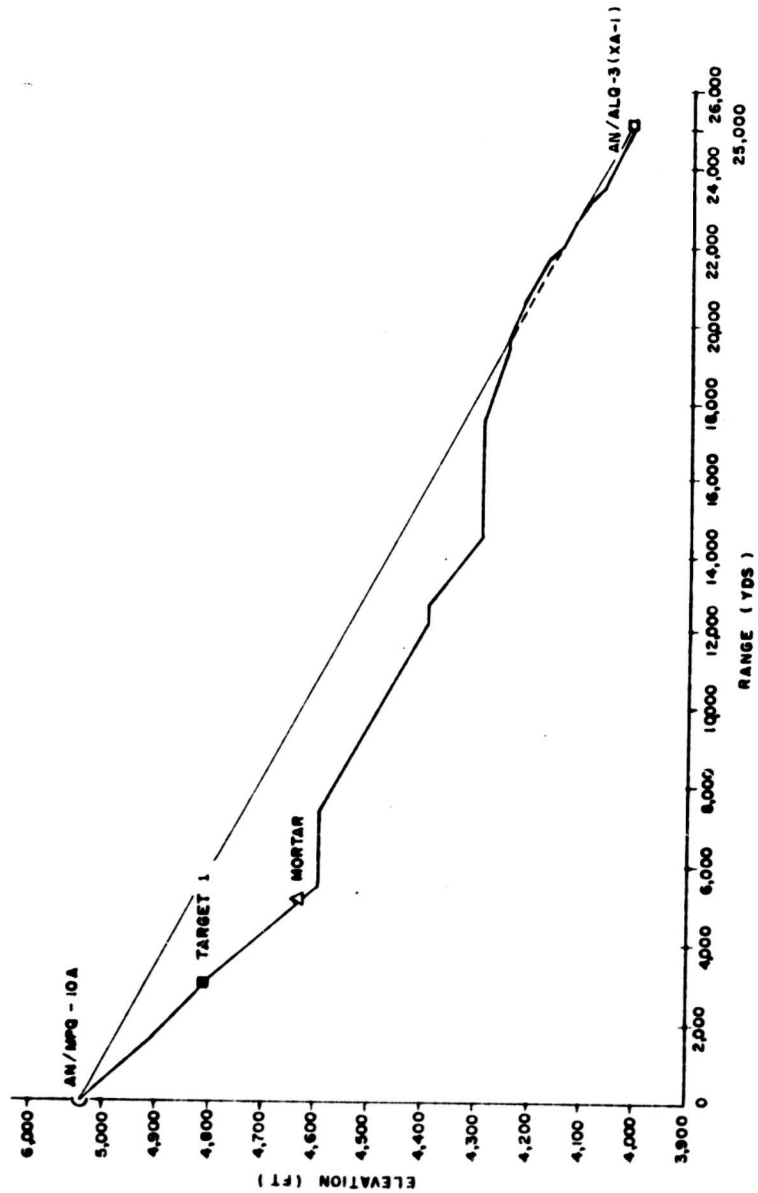


Fig. 13. Profile, indicating possible terrain masking, test 4, step 3

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Section VI. Jamming Interference and Effects of Terrain

12. TEST 5. INTERFERENCE OF THE AN/AIQ-3(XA-1) WITH FRIENDLY GROUND-BASED RADAR

a. Purpose

The purpose of test 5 was to determine the degree to which the AN/AIQ-3(XA-1) would interfere with friendly ground-based radar.

b. Procedure

The Radar Set AN/MPQ-10A was sited on slightly elevated terrain at the same site as in test 1 and placed in search operation. The radar's antenna was oriented at 0-deg aspect to the jammer site, which was located at various line-of-sight ranges from 4,000 to 26,000 yds, as shown in fig. 14. At each step range the jammer's antenna was oriented 180 deg in respect to the radar site. The jammer was initially tuned to the radar frequency by the use of an auxiliary signal generator. The generator was then used to activate the jammer, for a received signal is necessary to key the jammer transmitter. Noise-type modulation was used by the jammer throughout the test. At each range step the jammer's antenna was rotated through 360 deg in 45-deg steps.

c. Results

(1) At a range of 4,000 yds a very weak signal was received at the radar site, while the jammer's antenna was oriented 180 deg in respect to the radar site. The interfering signal was of such small magnitude that little difficulty would have been experienced in detecting weak echo signals. This condition continued to exist in all 45-deg increments with the exception of 45 deg each side of 0-deg aspect, where the signal became sufficiently strong to cause significant interference.

(2) At a range of 10,000 yds, no signal was received when the jammer's antenna was oriented 180 deg in respect to the radar. A very weak signal was received at orientations of 45 deg and 90 deg of the jammer's antenna in respect to the radar. The interference was significant at 22.5 deg either side of 0-deg aspect.

(3) At a range of 26,000 yds, no interference was detected at the radar except when the jammer's antenna was no more than approximately 30 deg either side of 0-deg aspect. Intense interference was produced when the orientation was only 5 deg either side of 0-deg aspect.

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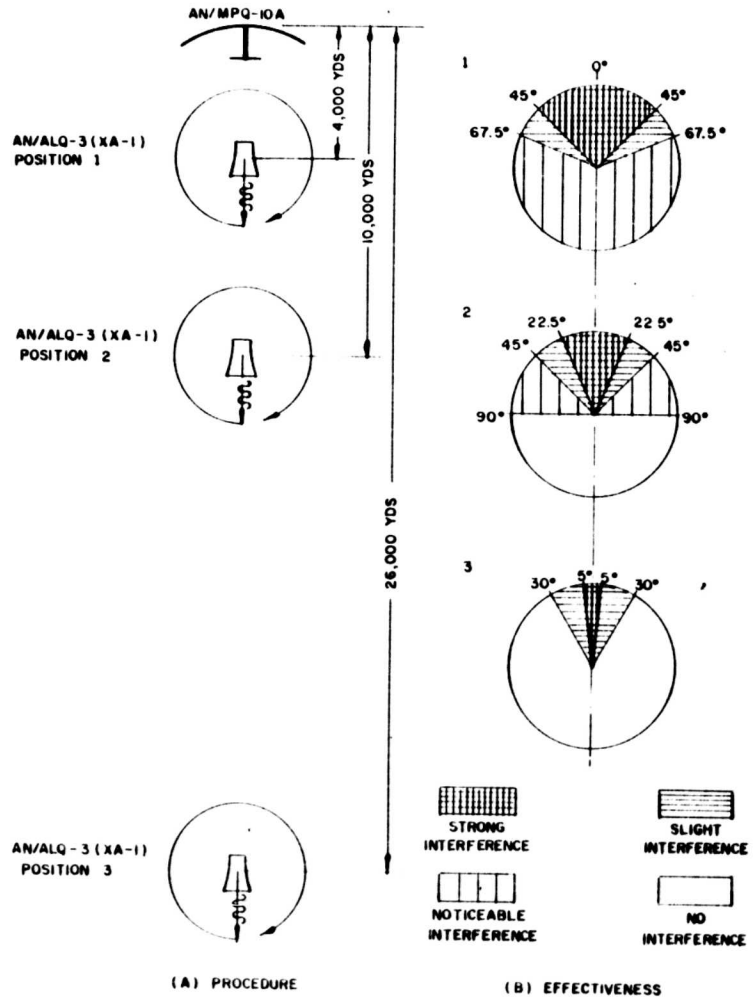


Fig. 14. Effectiveness of interference at various ranges and aspects

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13. TEST 6. EFFECTS OF TERRAIN ON JAMMING

a. Purpose

Test 6 is performed to determine the effect of terrain on the range and effectiveness of the AN/ALQ-3(XA-1) when it is used against a ground-based radar.

b. Procedure

The Radar Set AN/MPQ-10A was sited on ground slightly lower than the surrounding terrain and placed in normal operation. The AN/ALQ-3(XA-1) was located at a range of 7,050 yds and 6,400 yds, with a slight masking of terrain in each case. At each location the radar and jammer antennas were oriented at a 0-deg aspect, and the relative signal received was observed.

c. Results

(1) At a range of 7,050 yds a slight masking by intervening terrain existed near the radar site as shown in fig. 15. This consisted of an approximate depth of 10 ft at a range of 100 yds and extended to 250 yds from the radar. A reduced signal strength was detected by the jammer receiver and was insufficient for lock-on.

(2) The jammer was moved to a different site with the radar remaining the same. This site was at a range of 6,400 yds from the radar and 10 ft higher in elevation. The masking by terrain was approximately the same as in the first site, as shown in profile in fig. 16. The received signal was somewhat greater than in the first site, but still not sufficient for lock-on.

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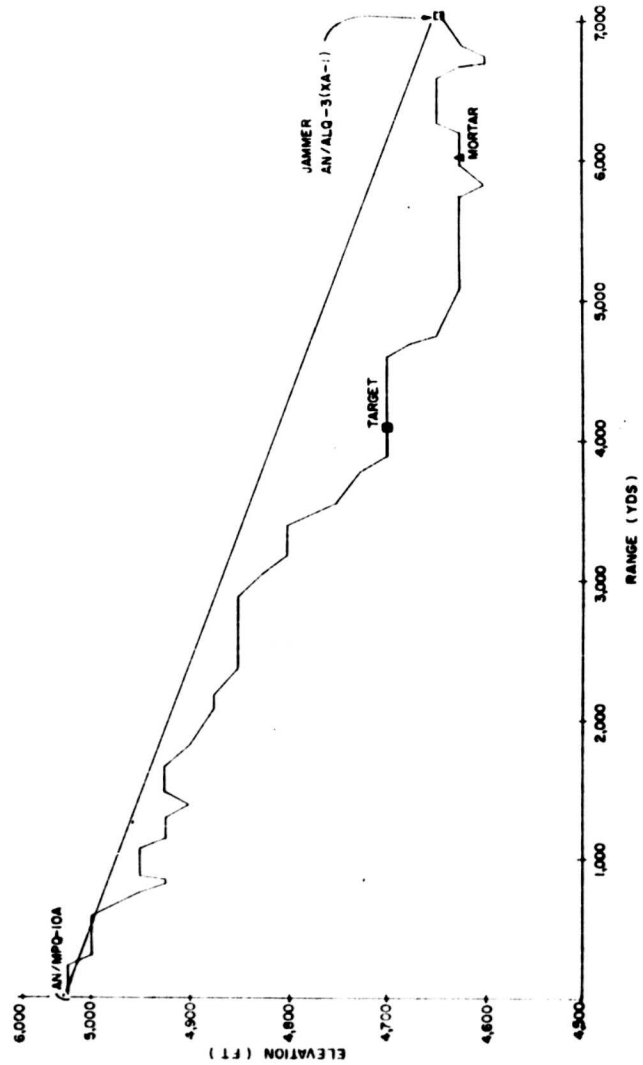


Fig. 15. Terrain masking location, test 6, step 1

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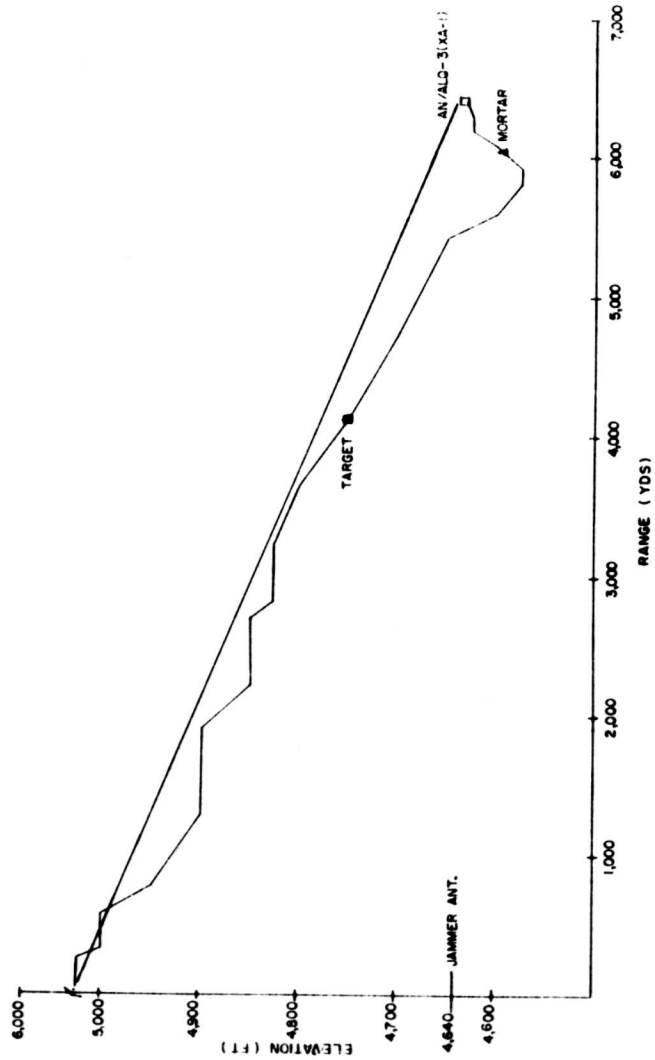


Fig. 16. Terrain masking location, test 6, step 2

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Section VII. Facility of Operation of the AN/ALQ-3(XA-1)

14. TEST 7, SETUP TIME

a. Purpose

The purpose of test 7 is to determine the time necessary to remove the AN/ALQ-3(XA-1) from a convoy and set it up for normal frequency search and jamming operation at a site.

b. Procedure

Three sites were used in performing this test. The time required for setup was noted from the time the 1/4-ton vehicle and trailer were stopped at a site until the receiver was in frequency search and jamming operation. The following steps in the setup were significant: starting power unit, removal of protective covers, mounting the antenna, and warmup of the receiver and transmitter. Two men working jointly were utilized to accomplish this setup.

c. Results

Results were recorded for each function in the process and are noted in Table I. The over-all time was not the total of the itemized intervals, since the antenna was mounted while the receiver and transmitter were warming up. This was possible as long as the plate power switch was OFF. Therefore, while a total of the itemized function times at the first site would be 24 min, the actual total time used was only 18 min, as shown in Table I.

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Table I. Setup Times for AN/ALQ-3(XA-1)

Over-all Times for Setup			
Operation	Time at first site (min)	Time at second site (min)	Time at third site (min)
Steps performed prior to warmup	8	6	3
Receiver and transmitter warmup	10	9.5	10
Total setup time	18	15.5	13
Itemized Function Times			
Start power unit (hand crank)	1	0.5	1
Remove portion of canvas vehicle top	3	2.5	2
Remove equipment cover	4	3	Not used
Mount antenna*	6	7	6.5
Receiver and transmitter warmup	10	9.5	10

* The antenna may be mounted concurrently with the receiver-transmitter warmup period; therefore a total of the itemized times will not equal the over-all time.

15. TEST 8. TAKEDOWN TIME

a. Purpose

The purpose of test 8 is to determine the time required to take down the AN/ALQ-3(XA-1) and prepare it for march order.

b. Procedure

Three sites were utilized in performing this test. The time required for takedown and preparation for march order was noted from cessation of the jamming mode until the vehicle was started. Significant steps in this procedure are (1) dismounting the horn antenna assembly, (2) replacing the canvas equipment cover, and (3) replacing the canvas vehicle top.

c. Results

The times required for takedown in the three installations are shown in Table II. Improvement was noted in the second and third trials with the elimination of the internal canvas equipment cover.

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Table II. AN/ALQ-3(XA-1) Takedown Times

Operation	Time at first site (min)	Time at second site (min)	Time at third site (min)
Dismount antenna assembly	3	4	3
Replace equipment cover	5	Not used	Not used
Replace canvas vehicle top	6	6	5.5
Total takedown time	14	10	8.5

16. TEST 9. MAN-MACHINE COMPATIBILITY

a. Purpose

The purpose of test 9 is to determine the man-machine compatibility in the operation of the AN/ALQ-3(XA-1).

b. Procedure

Following preliminary familiarization with the AN/ALQ-3(XA-1), an Observers Record Form and an Interview Record Form were devised. These Forms then served as a guide and record sheet during systematic observation and interview of four experienced AN/ALQ-3 operators.

c. Results

The following paragraphs comprise an evaluation of the man-machine relationship of the AN/ALQ-3(XA-1) and its operator:

Radio Set Control C-1378(XA)/ALQ-3

(1) Effective operation of equipment is limited by an undesirable functional arrangement of important operating controls:

(a) Power and transmitter switches are not positioned according to a logical operating sequence.

(b) The reset switch needs relocation to a position out of the way of other switches.

(c) Fuze lights do not necessarily appear over their corresponding switches as they should.

(d) Operators typically sit in the jeep during operation and view equipment from the side. In this position they cannot

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see the fuze lights to tell if the equipment is on. If blackout considerations permit, it would be desirable to provide the operator with a means of seeing from the side that equipment is operating.

(e) Operators indicated there is frequent confusion as to which control surface label applies to a particular switch. Labeling should be reworked as shown in fig. 17.

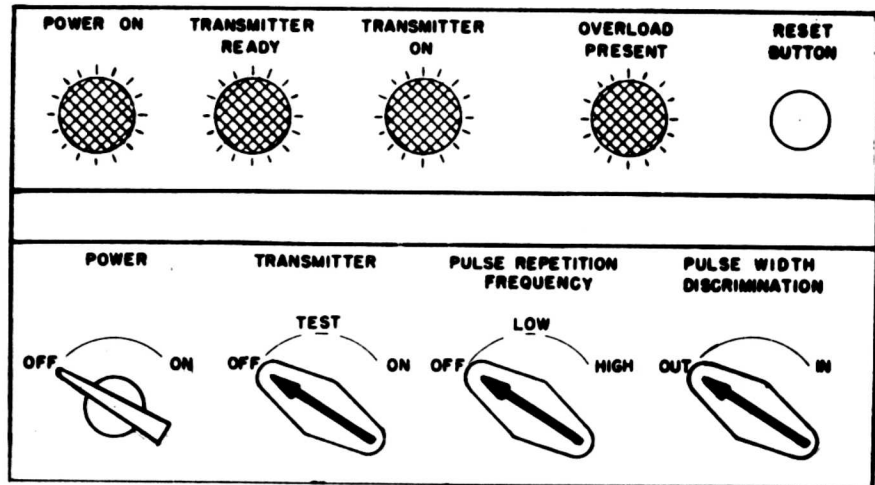


Fig. 17. Possible Redesign of Radio Set Control C-1378(XA)/ALQ-3

(2) Operator errors in triggering a wrong switch result from use of inappropriate types of switches. Toggle switches for power and reset are easily confused with other switches when the operator reaches blindly for them as he often has to do. Differentiation between these and other switches by "feel" needs to be provided.

Electrical Pulse Analyzer RF-57(XA)/ALQ-3

(1) Space requirements have dictated that this component be placed on its side. Lettering and numbering cannot be read satisfactorily in this position and needs to be placed along the new horizontal.

(2) Since the three knobs on the face of the component are used solely for switching in a "hold" type of situation, bar or pointer type knobs would be a more appropriate control than the present round knobs.

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Radio Receiver R-594(XA)/AIO-3

(1) Use of a screwdriver adjustment for control of the frequency range to be scanned is unnecessarily awkward. The two present controls are used frequently, and no reason for discouraging operators from their use could be determined. There is a need for round knobs with locking mechanisms which will prevent their vibrating out of position or their accidental turning.

(2) The pointer on the RF frequency dial hides the numbers of the scale. Numbers need to be relocated above the index marks so they can be easily seen.

(3) The attenuator control would be easier to grasp if it were bar-shaped or pointer-shaped rather than round.

Electron Tube Liquid Cooler HD-177(XA)/AIO-3

Much of the time operators do not face this equipment. The following shortcomings are evident at such times:

(1) A green light glows when there is a normal flow of liquid and goes out when normal flow is interrupted. Operators reported that the signal for interrupted flow is sometimes missed. Because of the potential seriousness of this deficiency a more effective signaling device is needed.

Antenna

(1) Operators mentioned the difficulty encountered in mounting the antenna, which must be held in an awkward position while six thumb screws are tightened. A slip-in mount with spring clamps for locking the antenna in place would be more desirable.

(2) The antenna leveling device is partially hidden from view by the antenna itself. If a mirror or piece of shiny metal were mounted behind the device to reflect the level indicator the antenna could be erected faster and more accurately.

Other Controls

(1) During search operations the operator must stop rotation of the antenna when an appropriate signal is seen on the RF Frequency Dial. The present antenna rotation toggle switch is unsatisfactory in that the operator can too easily turn from rotation to counter-rotation instead of to "off". Valuable time can be lost in this fashion. Either a different type of switch is called for, or the antenna should automatically stop scanning when a signal is picked up as shown in fig. 18.

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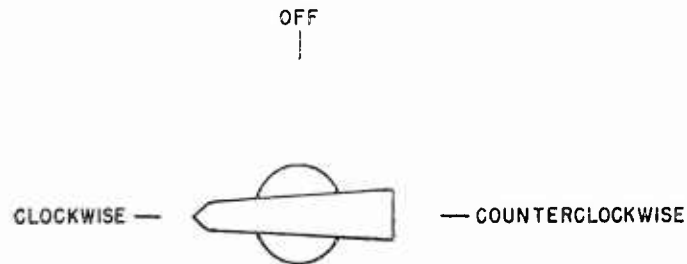


Fig. 18. Possible redesign of antenna rotation switch

(2) Operators reported it would be desirable to provide an alternative of manual tuning to the present automatic tuning. If signal strength is marginal the equipment does not, in some instances, become locked on the signal. With manual tuning the operator can set the jamming frequency to a known signal.

(3) The antenna speed control now utilizes two switches: one for fast or slow operation and another for variation within these two. Combining these functions in one knob would enable the operator to vary the speed more efficiently, but it must permit rapid movement throughout the speed range.

(4) The antenna speed control and all controls below it are difficult to read and adjust, because the side of the jeep is only eight inches from the equipment control surface. The operator is unduly handicapped in reaching and seeing into this narrow area. Repositioning of these controls is needed.

(5) To conform with the color code of the Radio Set Control the "Power On" light on the face of the modulation unit should be green.

Maintenance

In case of transmitter failure maintenance requires complete removal of the entire transmitter unit from the jeep. Consideration of a design which would permit easy access for minor maintenance jobs without removal of the entire transmitter is desirable.

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Miscellaneous

(1) At present there is no arrangement provided for the operator to sit facing the equipment. If the equipment were turned 90 degrees and the seat made adjustable to face the equipment, greater operator alertness to demands of the equipment and more adequate protection from the weather could be effected.

(2) Fasteners which secure canvas covers on the control side of the equipment require an undue amount of time to undo and often break off leaving equipment exposed to the weather.

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Section VIII. Discussion of Test Results

The optimum jamming modulation of the AN/ALQ-3(XA-1) against the AN/MPQ-10A was random noise. However, it was found that the AN/MPQ-10A was also susceptible to the sine-wave modulating frequency that corresponds to the frequency of the radar's conical scan. This frequency is variable as a result of possible speed variations of the spinner drive motor and in general this frequency would be removed by the AJ system of the radar receiver. Operation with the AJ system can be considered as the normal operating mode.

The AN/ALQ-3(XA-1) is an effective detecting device for intercepting ground-based radars operating in the S-band under line-of-sight conditions. The sensitivity of the jammer receiver was sufficient to maintain lock-on even when the transmitting energy was from a minor lobe of the radar set and intercepted by a minor lobe of the jammer's antenna. Terrain masking resulted in reduced minor-lobe reception with the greatest reduction occurring when the obstructions were near the radar site.

The AN/ALQ-3(XA-1) was 70 percent effective against the mortar-tracking Radar Set AN/MPQ-10A. This degree of effectiveness was maintained to a range of 26,000 yds when radar line of sight existed. Jamming was effective even when the jamming signal was directed into a minor lobe of the radar's antenna. Considerable latitude existed in the variation of relative bearing under line-of-sight conditions. This degree of variation was also evident when the AN/ALQ-3(XA-1) was in the track-while-jam mode. It was determined that the radar operator could not detect the presence of an echo signal from a mortar round when the jamming signal was transmitted continuously.

Operation of the AN/ALQ-3(XA-1) near friendly radar could be effected at a radar-jammer range of 10,000 yds. However, using terrain masking between the friendly radar and jammer and with operation at different frequencies, the friendly radar and jammer could be sited considerably closer together.

The average setup time for the AN/ALQ-3(XA-1) with two-man teams was 15.5 min and the average takedown time with the same number of men was 10.8 min. The elimination of the internal canvas equipment cover considerably reduced setup and takedown time.

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Section IX. Conclusions

17. CONCLUSIONS

It is concluded that

a. Jamming of ground-based radars can be accomplished by a ground-based jammer of the AN/ALQ-3(XA-1) type, provided line-of-sight conditions exist between the radar and the jammer.

b. Employment of radar equipment of the AN/APQ-10A type is such that to obtain the continual line of sight necessary for effective jamming, an additional installation of jamming equipment in an airborne platform is required.

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